Scan Processors
Sherry Miller Hocking

Experimental Television Center, 1978-1980

> "My experimental television is not always interesting but not always uninteresting; like nature, which is beautiful not because it changes beautifully, but simply because it changes."
>
> -Nam June Paik

> "The systematic study of scanning in symetric and asmetric,, geometric and ageometric, deteraministic-probalistic - indeterministic, periodic and aperiodic ways. The main reason for the quick success of my electronic art was that I gave up early the production of video-signals (information quantity: 4 million bits per second), in order to concentrate my efforts on the creation of unusual scanning patterns (very managable information quantity-. 15,000 and 50 bits per second). Especially the addition of third deflection yoke and triple modulation was a break through. The quick switching of various deflection patterns (for example spiral, oval, triangle, etc.) with adequate gate circuits as in chromatron color tv will enrich the variability by far. I an confident that the introduction of the computer to this already well proven area will bring immediate success."
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> -Nam June Paik 1966 in Flykingen Bulletin, Stockholm, 1967

> "The concept in the Rutt/Etra is that the Rutt/Etra changes the time in which you see parts of the picture. It's a machine that manipulates images in time. I see it as a time processor ... I would allocate that feature as Steve's and my contribution."
>
> -Bill Etra, in conversation with Woody Vasulka

> "I suggest 'Silent TV Station', which transmits only beautiful 'mood art' in the sense of mood music. What I'm aiming at with my Lissajous figures and other distortions is a television equivalent of Vivaldi,, or electronic Compoz. Lumia art will then became a permanent asset in the collections of millions of people. The 'Silent TV Station' will simply be there.. not intruding on other activities, and will be looked at exactly like a landscape or a beautiful bathing nude of Renoir. Normal TV bores you and makes you nervous; this soothes you."
>
> -Nam June Paik

> "If on a scale from one to one hundred, the present technology in a given area is zero and the possible technology in that area is one hundred, you should make always a machine that tries to be an eighty or a seventy-five. Then the research and development isn't a two year on-going development project that never stops while you're building the machine. You design a machine that in possible to build, you spend six months to a year doing it and you bring it out at a reasonable price and it doesn't do everything. It doesn't do everything that your mind can possibly conceive of, but it does a number of things competently. And you sell it."
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> -Greg Leopold, in conversation with Jon Burris

Signal processors, a keyer for example, can be defined as image-making devices which alter specific properties of the video signal. In contrast, a scan processor reorganizes images by acting on the systems which control the scanning motion of the electron bean; these devices do not directly change the signal or waveform but rather reorganize the way in which the signal is displayed. The shape and time frame of the electronic signal are the determiners of the appearance of the resulting image as it is displayed on the CRT. In a conventional CRT the deflection systems maintain the horizontal and vertical orientation of the raster, producing a full and stable rectangle of light. Because the signal processor acts on the deflection system, the means of displaying the image, rather than the signal itself, the appearance of the image is changed; the signal which defines the image remains unchanged. With the controls of the signal processor in appropriate positions, the CRT may act as a conventional monitor/receiver and an unprocessed image may be displayed.

In general, a scan processor consists of a CRT the normal deflection system of which is modified, a set of controls over the deflection system which alter the raster in specific ways and, finally, a rescan camera. Because the signal defining the image is not changed but only the appearance of the displayed image, the image transformations achieved with the processor must be reproduced optically; scan processors do not output a video signal which can be directly recorded. The reproduction of a scan-processed image is done by the technique of rescan; a video camera is pointed at the signal processor's CRT display and the image changes are re-photographed. The rescan camera can then be used as an image source for further processing. The rescan technique results in a degradation of the sharpness of the image; certain scan processors compensate for this by using a high resolution camera or display CRT. Instead of using a standard 525 line scan, high resolution systems employ 945, 1024 or other scan systems.

As a technique, rescan does not inherently produce any alterations of the image. The process can be utilized when a pre-recorded tape is used as a signal source in an Image Processing System if no genlock capability is available. Along with genlock, a tape may be simultaneously rescanned to superimpose two different treatments of the same imagery, or to alter the scale of the rescanned imagery relative to the genlocked tape] the change in scale is accomplished by changing the camera's position relative to the rescan monitor. For example, the rescanned imagery may be slightly enlarged or reduced or its position shifted. Because the scan lines of the monitor tend to be emphasized, rescan is sometimes used as a design element to achieve textural or linear definition of the image. Rescan has also been used as a means of broadcasting videotapes the signals of which do not permit either direct broadcast or transfer; in this case, the tape is played back on a monitor and the signal from the rescan camera is recorded or broadcast.

Scan processors can operate on a variety of image or signal sources. Live camera or pre-recorded information from tape or film, non-optically generated imagery derived from oscillators, and the output video signal from an Image Processing System are all possible sources. Audio signals generated by microphones, radios, audio synthesizers may also be used. Scan processing can be performed on the raster itself, with no image displayed.

In general, the types of image transformations possible with a scan processor include shape, position or placement, size, intensity and movement. The raster can be reversed along the XY axis by causing a reversal of the normal scanning operation. Reversal around the vertical dimension transposes right and left creating mirror images, while reversal around the horizontal dimension transposes top to bottom, creating an inversion of the image. Collapse of the vaster around the vertical axis produces a single horizontal line while collapse around the horizontal axis produces one vertical line. Simultaneous collapse of both horizontal and vertical create a single, centered dot. Collapse functions are achieved by removing from the horizontal and vertical deflection systems the electrical current which drives them back and forth and up and down. Changes of shape include the banding of the raster or image to conform to the shape of an input waveform. The image can also be moved around the screen or repositioned and rotated in two dimensional and apparent three dimensional space.

The Raster Manipulation Unit is a 'prepared television', a conventional television receiver which has been electronically modified to permit a wide variety of treatments to be performed on video images; the scan processing is accomplished primarily by the addition of electromagnetic yokes which control the horizontal and vertical deflection systems and by the application of signals to the yokes.

The unit is a receiver modified for monitor capability; all of the distortions can thus be performed either on broadcast signals or, when the unit is used as a monitor, on images from live or prerecorded sources. The distortions performed on the image by the unit result from the actions of audio signals on the yokes. Audio signals which are periodic and regular, such as sine or square waves, are normally used when treating a video image; these singals are derived from an audio or function generator or oscillator. However, any audio signal may be employed; these devices include audio synthesizers as well as more conventional components such as audio tape recorders, tuners, microphones or phonographs. These types of signals are most evident visually when used in conjunction with the horizontal or vertical collapse functions which reduce the raster to a horizontal or vertical line. These audio signals cause the line to distort in direct correspondence with changes in the audio signal; often the frequencies present in this type of signal are such that the distortions produced by their actions on a complete image may not be very noticeable.

The unit is also capable of reversing the raster around the vertical or horizontal axis, producing images which are reversed left to right or top to bottom in orientation. The raster reversal in combination with audio treatments generate an almost endless series of patterns which are highly controllable.

These basic and relatively simple techniques of scan processing were further developed by Korean artist Nam June Paik in collaboration with Hideo Uchida and engineer Shuya Abe during the period 1962-64. Initial experiments involved the placement of external magneto near the CRT; depending on the magnet's position, the raster would be deflected in different directions. Paik first exhibited the results of these and other explorations at 'EXPosition of music, Electronic television' at Galerie Parnass in Wuppertal, Germany in March of 1963; this is frequently referred to as the first video exhibition in the world. In June of 1964 Paik published

an essay in Fluxus Newspaper in which he outlined the 'dimensions of variability' of the raster manipulation unit.

The first level of variability was the distortion of a broadcast television image which he considered 'the most variable optical and a tidal event of our times'. The second level involved the modification of certain circuits of the receiver and variations of the horizontal and vertical control systems. The third level was the use of external waveforms derived from audio waveform generators, audio tape or live audio sources; these signals were applied to both deflection systems and the receiver's circuitry to create images modulated by the waveforms, with positive and negative areas interchanged. In the January 1965 exhibition 'Electronic TV and Color TV Experiment' at the New School for Social Research the vocabulary was enlarged to include raster reversal along the horizontal and vertical dimensions and size reduction of the raster, producing a horizontal or vertical line, and., again., the use of external magnets. In the notes for the exhibition, Paik mentions the experiments of Professor K.O. Goetz of the Kunst-akademie in Dusseldorf on the use of the computer to control the CRT, noting that computers, at that time, were too slow to achieve the goal. 'Moonlight Sonata' produced by Paik at WGBH-TV in Boston in 1969 for the program 'The Medium is the Medium' made use of these prepared televisions to generate abstract form and to distort images of Richard Nixon and other contemporary figures.

The impulses for the development of this 'scientifically rather unorthodox' method of scan control derived partly from Paik's involvement with the Fluxus movement and Happenings, his Eastern sensibilities, an interest in contemporary music, notably that of John Cage, and his own extensive academic background in music. He was also concerned with the notions of variability and the random in the arts and with the humanization of technology, allowing a greater degree of active participation by individuals. Although Paik never attempted the commercial marketing of the unit, documentation was completed by the Experimental Television Center through the support of the National Endowment for the Arts in 1978.

The complete unit contains a modified receiver/monitor with raster reversal and collapse functions, one stereo and one mono amplifier and three audio generators.

The standard small yoke on the receiver is an electromagnet; when an electrical magnet is passed through the small yoke it generates a magnetic field which deflects the electron beam in the CRT in a regular pattern of horizontal lines, the raster. The scanning process has both horizontal and vertical components. The yoke wires have been extended to two three-position switched. When the raster reversal switches are in the normal position., a raster with the customary left to right and top to bottom orientation is achieved. By reversing the direction of the electrical current through this yoke, the raster is reversed in either its top/bottom or left/right orientation or both simltaneous1y. This occurs when the switches are in the reverse positions. The normal scanning operation is actually reversed in orientation; the electron beam in the horizontal scanning process in deflected from right to left rather than left to right, while in the vertical scanning process the beam is deflected from bottom to top rather than top to bottom. When both switches are in reverse positions, the beam is deflected bottom to top and right to left simltaneously.

By removing the current from either the horizontal or vertical deflection systems of this yoke, one horizontal or vertical line is produced. If the current is removed from the horizontal, one vertical line is created. This indicates that the electron beam is not moving to the left or tight but is only being drawn downward on the CRT, producing a vertical line. Current removed from the vertical scanning operation produces a horizontal line because the beam is scanning left to right but it is not being drawn down. When no current is passed to either the horizontal or vertical systems, the electron beam is not moving either horizontally or vertically, and one point is produced.

The other yokes have been added to the unit, one color yoke and one continuous wind yoke. If a continuous current is passed through the horizontal portion of the color yoke, the effect of both large and small yokes is combined; the raster is shifted horizontally either to the left or right, depending on the direction of the current. If the continuous current is passed through the vertical component of the color yoke, the effect of both large and small yokes is combined to shift the raster in a vertical direction either up or down. The continuous wind yoke produces an S curve distortion of the raster.

The purpose of the audio amplifier in the system is to drive the yokes of the receiver/monitor. Because the yokes are electromagnets, they react to the audio amplifier in much the same manner that a sound speaker responds.

The audio generators provide audio signals to the amplifiers in much the same way that a tuner or turntable provides a source of periodic or continuously repeated., regular waveforms. They are normally used when distorting a full raster. Frequencies which are multiples of the vertical sync rate of 60 Hz produce the most obvious and symmetrical distortions; examples of such frequencies include 60 Hz., the vertical sync rate multiplied by 1, 30 Hz., half the vertical rate, and 90 Hz, vertical sync rate multiplied by 1.5. This range of frequencies is usually found on audio generators. It is possible to use an audio tape recorder, tuner or phonograph as a source for audio signals rather than an audio generator; in this instance the signals which will distort the raster are not necessarily periodic and may contain a wide range of frequencies., some of which may have little or no visible effects on the raster. These non-periodic waveform sources produce more evident distortions if the raster is collapsed first to a horizontal or vertical line. In this case the line will visibly respond to most of the frequencies found in signals derived from audio tape decks, microphones, tuners of phonographs. The lines also respond to audio signals originating in the audio generators. Lissajous patterns can also be created on the system.

During the late 1960s a number of other artists and engineers were also developing television-based kinetic imaging systems. The ‘TV as a Creative Medium’ exhibition at the Howard Wise Gallery in New York in 1969, in addition to Paik’s work, included works by Earl Reiback and Joe Weintraub. ‘Audio-Controlled Television’ by Weintraub transfomed music into color television images on a conventional color receiver; the volume of the audio controlled the brightness while the pitch controlled color. The red, green and blue electron guns of the color receiver were governed by the frequencies of the audio divided into low, middle and high ranges. The patterns generated were dependent on the interaction of volume and pitch. Reiback, who was educated in nuclear engineering at Massachusetts Institute of Technology before turning to luminal art. exhibited a series of three pieces, all of which involved material changes to the

inside of the CRT. In 'Electron Bean' the phosphor coating of the CRT was removed and the tube filled with neon to reveal the flow of electrons in the scanning beam; by manipulating external magnets the beam could be bent. 'Suspension' involved the construction of a phosphor-coated grid suspended inside the CRT which received the broadcast image; the back of the tube was coated with a colored phosphor which glowed when hit by the scattered electrons of the beam. A phosphor-coated screen was mounted perpendicular to the face of the CRT in 'Thrust', glowing when bit by the beam.

Sid Washer's background includes early childhood experiences with photography and electronics; he cites also the profound effects of the Disney animation film 'Fantasia' which he saw in the late 1930s and of Thomas Wilfred's Lumia developed early in this century and based on the concept of light in notion as an art medium. His educational background is in electrical engineering and other influences include filmmaking and editing, particularly in the area of animation.

Washer's contribution to video imaging systms lies also in the area of scan processing, making use of the deflection circuitry to generate patterns rather than the customary raster. Developed the 1960s, these prototypes have no provision for an external video source as input, since video cameras and oscillators at that time were prohibitively expensive. Initial experiments resulted in 1963 in a color television which displayed Lissajous patterns by connecting the deflection circuitry to amplifiers to modulate the red, green and blue beams separately. By 1965 he had developed a 3-D color music device called the 'Albatross' which was designed as a performance instrument. The device used the modified color television which was reflected in a vibrating mirror surface driven by a loudspeaker at a specific frequency; the patterns on the color set were controllable in terms of size and position, and provision was made for an external audio source, usually a phonograph, as an input. The vibrating reflecting surface created apparent three dimensional effects. The system was essentially a pattern generator; it could not act on a full raster image because the technology required for rapid sweep of the beam was still beyond an acceptable price range for individual application. Images from this system were rescanned onto film. This device was exhibited, and a number were sold; it may have influenced Paik's development of the concepts involved in his unit.

By the late 1960s the design for a driven deflection system was nearing completion; the amplifiers were, Washer felt, almost fast enough to run the sawtooth waveform needed for the generation and deflection of the raster as opposed to the generation of Lissajous and other patterns. Washer also employed function generators, providing a variety of waveforms, and an audio synthesizer, both of which at that time were becoming more accessible; these were used to control the patterns, but the outputs were not able to generate the needed high frequency sawtooth. Around 1972 Washer developed a proposal in which he specified the parameters of the system, which was modular in design with appropriate signal patching. The system consisted of a display processing unit as well as control units and generated a full color display. The patterns generated could be controlled in real-time in terms of width, height, brightness, color balance and spatial orientation; they were described by Washer as similar to 'computer-type graphics' generated without a computer. The system had provision for video inputs., which he specified as character special effects and waveform generators, as well as audio sources and systems. In 1974 Washer began work with Steve Rutt and Bill Etra.

In California Bill Hearn had worked since the mid 1960s on the development of a system for the production of color Lissajous patterns using phaselocked oscillators. Just prior to 1970 Hearn designed and built the Vidium, an XY display system which used a color CRT. The XY display was controlled through stereo microphones and the color was related to the speed of the electron beams. The red, green and blue guns were modulated by the velocity of the beam; each spectral color was assigned to a velocity and therefore changes in velocity produced color changes. Its prinary use was in the direct generation of images from audio by electronic musicians and it was never developed commercially. It was subsequently loaned to the Exploratorium, an activity-based science and technology museum in San Francisco. Although Hearn himself didn't consider the Vidium to be a video tool since it relied on the functions of a conventional color television set, Hearn made significant contributions in the development of imaging systems.

Also working in California at the National Center for Experiments in Television at KQED-TV, Don Hallock conceived of the Videola, exhibited at the San Francisco Museum of Art in 1973. A sculpture, the Videola was a display system for live images or videotapes. Physically it was configured like a pyramid on its side with a color monitor at the top and mirrors lining the sides, located in a darkened room. The usually rectangular display surface of the monitor was multiplied by the mirrors, producing an apparent sphere and creating a kaleidoscopic effect. Unlike all of the scan processing devices discussed, this device depended on the multiple reflections of a single unmodified image from a monitor and did not operate on the scanning or deflection systems at all; there were no controls available to alter the dynamics of the image. It was designed primarily to provide an alternative to single monitor, multiple monitor and video projector display systems, freeing the artist from the rectangle dictated by the CRT. For the exhibition a series of image processing tapes were shown, including those by Steven Beck, Bill Gwin and Hallock.

The Rutt/Etra scan processor., in its initial stages of development, was an oscilloscope using pots to change deflection voltages on the yokes. In the production model of the Rutt/Etra the display CRT, which was rescanned, was available in 525 or 1050 line scan systems. Control was either manual or pre-programmable through the use of control voltages. The dual trace production models of the system offered control over height,, width, depth, shape, brightness, position and movement as well as rotation in two and apparent three dimensional spaces. The height control on the display control unit permitted reduction of the raster image to a line, expansion of the inverted image beneath and horizontal rotation. The width control allowed reduction, inversion and vertical rotation. Positioning control allowed vertical and horizontal placement,, and horizontal and vertical axis adjustment was accomplished by a centering control. Variations of brightness were produced by an intensity control.

There were five standard modules, termed Animation Control Modules, on the production model. A summing amplifier allowed the combining of different functions. The diode module divided waveforms and timing ramps. A ramp generator permitted control over speed and period of time. The audio interface, described as an envelope generator, allowed control signals to be input from other audio devices; it varied the attack and decay times of the input without affecting any other signal parameters such as gain. Two waveform generators controlled frequency, wave shape, duty cycle, amplitude and frequency modulation; the oscillators could be triggered on

either horizontal or vertical. There were three optional modules available. The joystick, an XYZ controller, was a manual interface; it could be assigned control over any three parameters and had integrators which helped to smooth the motion. The ramp programmer allowed the operator to perform more than a single move. The third optional module, the repositioner, was intended for more commercial applications; a digital device, it allowed the positioning of a pre-recorded or live image anywhere on the screen, with results similar to a horizontal pan or travelling mat. It functioned not by storing fields or frames but by horizontally or vertically repositioning the original sync and reinserting this re-timed sync which was then used to drive other devices in the system. Thus an image could be shifted horizontally or vertically on the screen, with an indication of how far from the center the image had been moved.

The Rutt/Etra was collaboratively designed by Bill Etra and Steve Rutt in association with Sid Washer, who assisted in the design and construction, and Greg Leopold, who was primarily responsible for the packaging of the system. Rutt's contribution was in the area of electronics and engineering in which he had been engaged since childhood; he had also been working with commercial applications of strobe technology. Etra's background included art history as well as commercial photography and filmmaking; he introduced Rutt to video and was himself involved in videomaking. Leopold had been exposed through his father's business to some of the early leaders in the field of electronics and had a background in business management as wall as the design of loudspeakers. The motives for the development of the prototype Rutt/Etra in 1973 lay in an impulse to expand creative uses of technology and to provide to individual artists access to a sophisticated imaging systems. With the unit the artist could produce effects, for example the rolling of an image through the raster, which were difficult or impossible to perfom by hand through the manual manipulation of graphics. Between 1971 and 1973 Etra had also seen several other independently produced video imaging systems, including the Siegel Colorizer; Washer, Rutt and Etra all realized the necessity of approaching the design of the unit as a system, to facilitate the ease of use.

In 1971 Etra saw a Paik raster manipulation unit at the Television Lab at WNET-TV in New York; he felt that because Paik's unit was AC coupled it could only allow waveform distortion. Etra was interested in a modification to this unit that allowed for zooming and panning, the permanent placement of the image at any position within the raster. The Paik unit allowed for the placement of an image within the raster but it was not permanent. Around this time the Etras, Bill and Louise, were also working on installations and videotapes., for example 'Mars and Optic Aspect', in which oscillator imagery played a part; the oscillators at that time were not locked to sync, but were input directly to monitors and rescanned; this situation eventually resulted in the development in the Rutt/Etra of summation waveforms and syncable oscillators. This meant that the waveforms could be stabilized on the screen and added together. The works of Ed Emschwiller, 'Thermogenesis', for example, and that of Walter Wright were also influential; they had been achieved with the system at Dolphin Productions, which was, in general, not accessible to individual artists.

During 1972-73 with support from the Now York State Council on the Arts through the TV Lab at WNET and with an investment of personal funds, the Rutt/Etra was prototyped. It began, according to Rutt., as a modified Paik unit but differed from that system in a number of ways. It consisted of modular components, a design consideration which allowed for expansion of the

svstem. It was designed and built relying on circuitry information and parts then available and on the functional analysis and use of integrated circuits rather than on the use and modification of surplus equipment purchased off the shelf as Paik had done. The design and ultimately the manufacture of the unit was possible, in part, because by then the cost of integrated circuits had dropped enough to permit the actual construction of the device. Much of the technical information used in the design of the Rutt/Etra lay in the public domain. Flight simulators developed for military applications in the 1950s used a rescan and deflection system. Washer and also Paik cite television service manuals and technicians as sources for information regarding methods of altering the scanning system; Paik often stated that one of his methods of design involved the duplication of circuits and eventually images that were considered to be malfunctions by television service technicians. The early designs of Paik and Washer were also influential. In a broad sense, the Ratt/ Etra technology already existed but required repackaging and a method of application. Further the Rutt/Etra was DC coupled, a fact which permitted positional movement in contrast to waveform distortion available from Paik's unit. With DC coupling, the image could be moved to a position and stabilized at that location; with the Paik unit the image would not remain in the new position.

After the system was prototyped, the decision was made to develop it commercially, in part to make back the original personal investment. The original concepts of the prototype were retained, but the production model was redesigned. After several models were built, a video retail company was selected to act as distributor, providing a relatively stable financial base for continued production and development. The intended market initially included smaller cultural and educational institutions and individual artists. The improvements in circuitry, the fact that the units were built individually rather than mass produced and the fact that the attempt to keep the cost low by increasing the sales volume failed, all necessitated an increase in price which ultimately put the unit beyond the market for which it was originally envisioned.

The following essay, "Didactic Video" by Woody Vasulka appeared in Aferimage, October 1975.

Although the Scanimate and Caesar systems used at Computer Image Corporation have primarily comercial applications, they made an important conceptual contribution to the design of computer-controlled video 'animation' devices and have influenced independent design efforts. Lee Harrison III whose background includes fine arts as well as engineering formed Computer Image Corporation in 1967 and was instrumental in the development of these systems.

Both systems at a fundamental level involve the rescanning of a monitor; the raster display is reshaped through the application of different voltages to the deflection systems, and in this way is very similar to the Rutt/Etra and Paik units. The introduction of the computer to this system allows the changing voltages to be 'memorized' and stored and then played back in sequence to create movement in real tine. The display is then rescanned and the output of the camera recorded.

Scaninate, the predecessor of Caesar, was developed in the early 1970a and was awarded an Emmy in 1972 by the Television Academy. It is an analog computer system used primarily for graphics animation. A high resolution camera, usually looking at a high contrast black and white

film transparency, is input to the analog computer animation controller; this permits manual control over elements such as size, intensity, placement or rotation by generating varying voltages which are then applied to the horizontal and vertical deflection systems of a high resolution monitor or scan converter. The changing voltages create different scanning patterns on the raster and therefore different treatments of the image, displaying images which correspond to the voltage changes. The computer creates and stores these sets of voltages and then plays them back in real time on the rescan system; a second camera views the rescan monitor and its output is then fed to a colorizer. The colorizer operates on a set of five gray scale values; each gray level has separate controls over red, green and blue. The output of the colorizer can then be recorded.

The analog computer allows a range of changes within a compositional element., for example size, through the manipulation of knobs; the range then is continually variable between its lowest and uppermost limits. Because the rescan technique is used, the original image to be animated is fed directly into the system through a camera and does not need to be translated into a digital code first. A purely digital system, which operates on a yes/no or on/off principle, would require that the original image first be translated into a mathematical formula or a set of locations which specify or re-map the image point by point. The decision to use an analog computer was made, in part, to eliminate this level of translation.

Caesar, or Computer Animated Episodes using Single Axis Rotation, is a hybrid analog/digital system used primarily for character animation. The artwork, again, is converted to a transparency; before it is input to the system through the camera, it is divided into a maximum of eight sections, stacked vertically. Normally this means that each section of the image that will move independently, is in a separate section. Within each horizontal division several variations, for example position of hands, can be arranged; by controlling the blanking window of the video signal, only one of these variations will appear within the frame at anv particular time, but any one of the variations can be substituted in any desired frame. A blanking window can be most easily understood as a rectangular ‘window’ the same size and shape as the raster. Any part of the image, or signal not lying inside the window is blanked. The blanking window may be stationary and the raster moved through or the window itself may move over the image. In either case the motion causes certain parts of the raster image to be blanked or disappear. Each area that is to have its own color is assigned a gray value; any color can then be assigned to that area defined by the gray value. Areas with the same gray value can have the same or different colors; the color of a particular gray value can also be changed during the animation sequence. For each of the eight sections, the operator can control size, shape, position, rotation and color; by changing the control knobs, voltages are generated, applied to the rescan monitor and are then displayed as image transformation. By manipulating the controls the appearance of the complete frame is defined. The operator can then define a maximum of eight complete frames, called key frames, and specify the time interval between these frames. Once all of the key frames are composed, the computer generates the transition frames between these frames. The digital computer allows for a precise timing and positioning of the sequences and has a sufficiently large memory for complex animation. Through techniques of keying, backgrounds or additional characters may be inserted.